An Inventory of Stream Habitat in the Jackson River, George Washington - Jefferson National Forest, Virginia

Center for Aquatic Technology Transfer
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Introduction

The George Washington-Jefferson National Forest (GW-JNF) and cooperators are assessing stream habitat conditions of the Jackson River on federal and private land to develop current and future restoration projects. We used the Basinwide Visual Estimation Technique (BVET) (Hankin and Reeves 1988; Dolloff et al. 1993) to inventory habitat in over 33 kilometers of the Jackson River throughout most of Bath County, VA in July of 1999(Figure 1). The use of BVET allowed us to estimate total habitat area, percentage of pool and riffle area, and to classify the stream substratum particle size distribution. We also mapped the distribution of large woody debris (LWD), inventoried riparian land use and vegetation, and estimated the 100-year floodplain width for the Jackson River.

The survey was split up into three sections based on land ownership: lower (mostly private), middle (U.S. Forest Service), and upper (mostly private). The lower section started just upstream from Lake Moomaw at the confluence of Back Creek and ended 13.8 kilometers upstream at the U.S. Forest Service boundary. The middle section started at the same property boundary and continued through U.S. Forest Service land 11.8 kilometers ending at the confluence of Ned Hollow. The upper section started at Ned Hollow and continued 7.6 kilometers upstream through both federal and private land to where it ended approximately two kilometers downstream from the Bath-Highland County line. The upper section was supposed to finish at the county line but ended prematurely due to the unwillingness of landowners to allow access (Figure 1).

Methods

Two-stage visual estimation techniques were used to quantify habitat. During the first stage, all habitat units were classified and the surface area and depth were estimated. Sampling strata were based on naturally occurring habitat units such as pools (an area in the stream with low water velocity, streambed gradient less than zero, and a smooth water surface), riffles (an area in the stream with moderately steep gradient, shallow water, relatively high velocity, and turbulent surface), glides (an area in the stream with moderate to low water velocity, gradient at or near zero, and uniform depth), cascades (an area in the stream with very high velocity, turbulent surface, and steep gradient), and braids (an area in the stream where multiple channels occur regardless of habitat type).

Habitat in each section was classified and inventoried by a two-person crew. One crew member identified each habitat unit by type, estimated surface area, estimated the average and maximum depth, and substrate composition for each habitat unit. This crew member determined substrate embeddedness in pools. Embeddedness was defined as an area on the stream bottom where larger particles were surrounded by at least 35% or more smaller particles (pers. comm. Gary Kappesser, GW-JNF Hydrologist). Average depth of each habitat unit was estimated by taking depth measurements at various places across the channel profile with a graduated staff marked in 5cm increments. The length (0.1m) of each habitat unit was measured with a hip chain. Temperature was taken three times daily: early morning, noon, and afternoon at quitting time.

Another crew member classified and inventoried LWD within the stream channel, identified Rosgen's channel type (Rosgen 1996), and bank buffer type associated with each habitat unit. This crew member also recorded the data on a Husky Hunter field computer. LWD was divided into four classes: 1) less than 5m long, less than 55 cm in diameter, 2) less than 5m long, greater than 55cm in diameter, 3) greater than 5m long, less than 55cm in diameter, and 4) greater than 5m long, greater than 55cm in diameter. All LWD less than 1m long and less than 10cm in diameter were omitted from the survey. Rosgen's channel types were restricted to A, B, C, D, and F (pers. comm. Gary Kappesser, GW-JNF Hydrologist). Stream bank buffer type was based on categories determined by biologists on the GW-JNF. Type 1 buffers had stream banks that were completely forested; Type 2 buffers had a mixture of pasture land, trees, and scrub vegetation; and Type 3 buffers were restricted to pasture land.

The first unit of each habitat type selected for intensive sampling (accurate measurement of surface area - second stage sampling) was determined randomly. Additional units were selected systematically (one unit out of 10 for each habitat type). The widths of these systematically selected habitat units were measured with a 30-m tape at intervals ranging from about 1 m to 15 m. Interval size was determined by the length and the morphology of the unit (e.g., intervals of measured widths increased with increasing unit length).

The relationship between the estimated surface area and the measured surface area typically is strongly and positively correlated when the estimates are made by experienced personnel. Visual estimates were corrected by multiplying all estimates by a calibration ratio (Hankin and Reeves 1988). The calibration ratio (Q), the estimated true total area (M) and the variance of the area estimator V(M) were calculated separately for each habitat type and each section.

In each of the systematically selected riffles we also measured the stream channel width (m) at bank full and estimated the riparian width (m) as described by Harrelson et. al 1994. We used this information to describe the channel and flood plain associated with each section. Temperature (Celsius) was also measured at different intervals in each section.

The corrected estimates of total habitat area were computed using a Microsoft Excel spreadsheet macro created by Craig Roghair (140 Cheatham Hall, VA Tech, Blacksburg, VA 24061-0321) based on BVET calculations found in Dolloff et al. 1993. Data were summarized using Excel spreadsheets.

Results

Lower Section

We identified 138 pools and 94 riffles in the 13.8 kilometers of the lower study section. Visual estimates of habitat area were paired with measured habitat area for 15 (11%) pools and 10 (11%) riffles. We estimated that the lower study section contained 76% pool habitat (202,940.6 ± 15,394.8 m^2) and 24% riffle habitat (64,063.4 ± 8,854.9 m^2) (Figure 2). Total area was estimated for pools and riffles using correction factors (Q) of 0.94 and 1.13, respectively.

Maximum depth in this section ranged from a mean 44.3 cm in riffles to 88.6 cm in pools (Figure 3). Likewise, average depth ranged from a mean of 22.6 cm in riffles to 50.1 cm in pools (Figure 3). The mean average residual depth was 37.8 cm (Figure 3). The average temperature of the lower study section was 23.9 degrees Celsius.

We identified cobble as the most common (modal) dominant and subdominant substratum for pools in the lower study section, but boulder and bedrock were also relatively common (Figure 4). In riffles, the common dominant substrata was cobble, whereas equal amounts of cobble and boulder made up the subdominant substrata (Figure 5). Fourteen percent of the pools in the lower section contained substratum that was 35% embedded.

The lower section contained about 102 pieces of LWD per kilometer (Figures 6 and 7). This amount fell well within the desired-future-conditions (DFC) of 78 to 186 pieces per kilometer identified in the GW-JNF forest plan. However, only 6 pieces per kilometer of the larger size class were present. Large pieces are the most stable and most capable of forming instream habitat and providing cover for fish (Figures 6 and 7).

The lower section included about 52% of channel type C, 41% of channel type B, and 7% of channel type A (Figure 9). The total riparian width for the lower study section averaged 193 meters wide (Figure 8). The common (modal) buffer for the left and right bank was type 1(forested): 61.2% of the left bank and 44.4% of the right bank were forested (Figure 10).

Middle Section

We identified 99 pools and 66 riffles in the 11.8 kilometers of the middle study section. Visual estimates of habitat area were paired with measured habitat area for 17 (17.2%) pools and 11 (16.7%) riffles. We estimated that the middle study section contained 77% pool habitat (140,311.2 $\pm$ 3,037.9 m^2) and 23% riffle habitat (41,617.9 $\pm$ 3,109.5 m^2) (Figure 11). Total area was estimated for pools and riffles using correction factors (Q) of 0.93 and 1.09, respectively.

Maximum depth in this section ranged from a mean 39.0 cm in riffles to 80.4 cm in pools (Figure 12). Likewise, average depth ranged from a mean of 20.7 cm in riffles to 40.8 cm in pools (Figure 12). The mean average residual depth was 31.8 cm (Figure 12). The average temperature of the middle study section was 23.6 degrees Celsius.

In pools, we identified the most common dominant and subdominant substrata of the middle section as cobble and boulder, respectively. There were also extensive amounts of large gravel present in the pools (Figure 13). The common dominant substrata of riffles was cobble, but the common subdominant substrata was made up of mostly boulder (Figure 14). The substrate was not found to be 35% embedded in any of the pools surveyed in the middle study section.

In the middle section there were about 64 pieces of LWD per kilometer, which does not meet the DFC's lower limit of 78 pieces per kilometer (Figures 15 and 16). This section only contained about 14 pieces per kilometer of the largest size class of wood (Figures 15 and 16).

Rosgen channel type C was the most common channel type in the middle study section (Figure 18). The total riparian width for the middle study section averaged 158 meters wide (Figure 17). The common (modal) buffer for the left and right bank was type 1(forested): 81.7% of the left bank and 68.3% of the right bank were forested (Figure 19).

Upper Section

We identified 79 pools and 68 riffles in the 7.6 kilometers of the upper study section. Visual estimates of habitat area were paired with measured habitat area for 13 (16.5%) pools and 12 (17.7%) riffles. We estimated that the upper study section contained 69% pool habitat (97,362.3 $\pm$ 16,283.2 m^2) and 31.0% riffle habitat (43,802.6 $\pm$ 3,038.7 m^2) (Figure 20). Total area was estimated for pools and riffles using correction factors (Q) of 1.12 and 1.09, respectively.

Maximum depth in this section ranged from a mean 40.7 cm in riffles to 84.5 cm in pools (Figure 21). Likewise, average depth ranged from a mean of 25.7 cm in riffles to 50.3 cm in pools (Figure 21). The mean average residual depth was 63.5 cm (Figure 21). The average temperature of the middle study section was 24.5 degrees Celsius.

We identified cobble as the most common dominant and subdominant substratum for pools in the upper section, but large amounts of boulder and large gravel were also common (Figure 22). In riffles, the most common dominant and subdominant substrata were cobble and boulder, respectively (Figure 23). Only 5% of the pools in this section contained substrate that was at least 35% embedded.

This upper section contained about 53 pieces of LWD per kilometer, which also does not meet the DFC's lower limit of 78 pieces per kilometer (Figures 24 and 25). This section only contained about 3 pieces per kilometer of the largest size class (Figures 24 and 25).

The upper section's Rosgen channel type included 95% of channel type C, and also included 5% of channel type B (Figure 27). The riparian width of the stream in the upper study section averaged 330 meters wide (Figure 26). The common (modal) buffer for the left and right bank was type 3 (pasture land), 56.8% of the left bank and 52.3% of the right bank (Figure 28).

Discussion and Recommendations

We photographed and cataloged multiple areas of bank erosion throughout the study area. We also found wider average channel widths in the lower (29 meters) and upper (34 meters) sections of the study area than in the middle study section (20 meters). This likely is due to the lack of streamside vegetation in the lower and upper sections.

The lack of streamside vegetation also is evident in the amounts of LWD located throughout the stream. The middle and upper sections fell short of the DFC for wood per kilometer. The lower section met the DFC for wood per kilometer but much of this wood fell in the gorge area in the lower 1.4 kilometers. The additions of streamside vegetation may allow for future increases of LWD in the river. Increased LWD, especially the larger size class, could increase stream and bank stability throughout the system.

During the survey rainbow trout (*Oncorchynchus mykiss*) and brown trout (*Salmo trutta*) were observed in the Jackson River. The preferred temperature range of rainbow trout is 12 to 19 degrees Celsius, and brown trout have an optimum temperature range of 18 to 24 degrees Celsius (Jenkins and Burkhead 1994). During the summer in the Jackson River, temperatures average approximately 24 degrees Celsius, or the upper limit for trout. We observed large numbers of trout were observed congregating around the springs located throughout the river. The springs apparently provide temperature refuge during the warm seasons. Future research should focus on year round temperature profiles and on locating temperature refuges that are used by the coldwater species.

The revegetation and protection of the streamside areas are necessary steps to restore sections of the Jackson River. Vegetated stream side areas provide stabilization of the banks, increase LWD input, and stream shading (which would lower stream temperatures). We recommend that approval be sought to complete the survey of the Jackson River.

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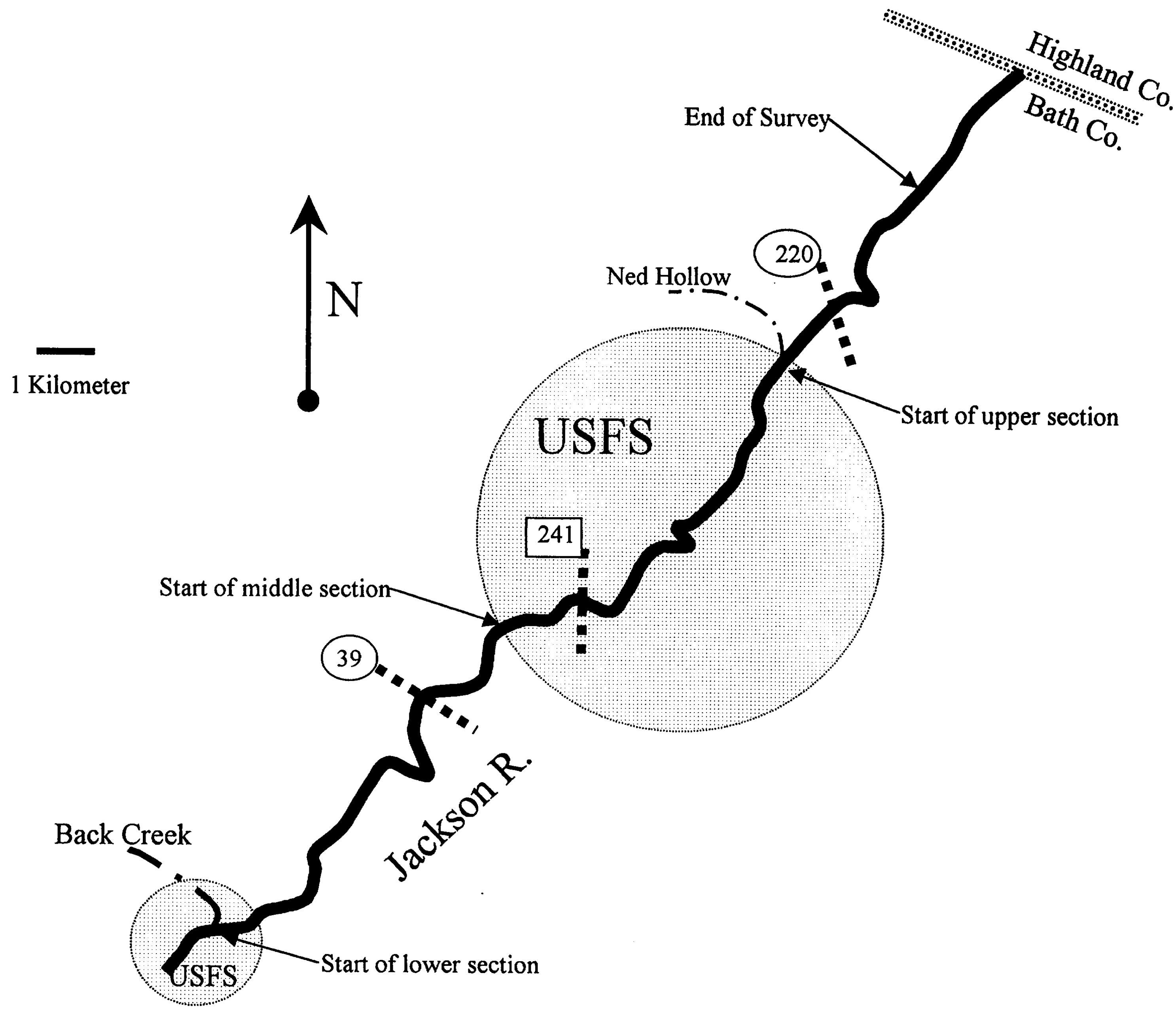


Figure 1. A map of the Jackson River watershed above Moomaw Lake. The three study section starting points are shown along with the USFS sections of the river. The important roads and tributaries and the county boundary are also represented.

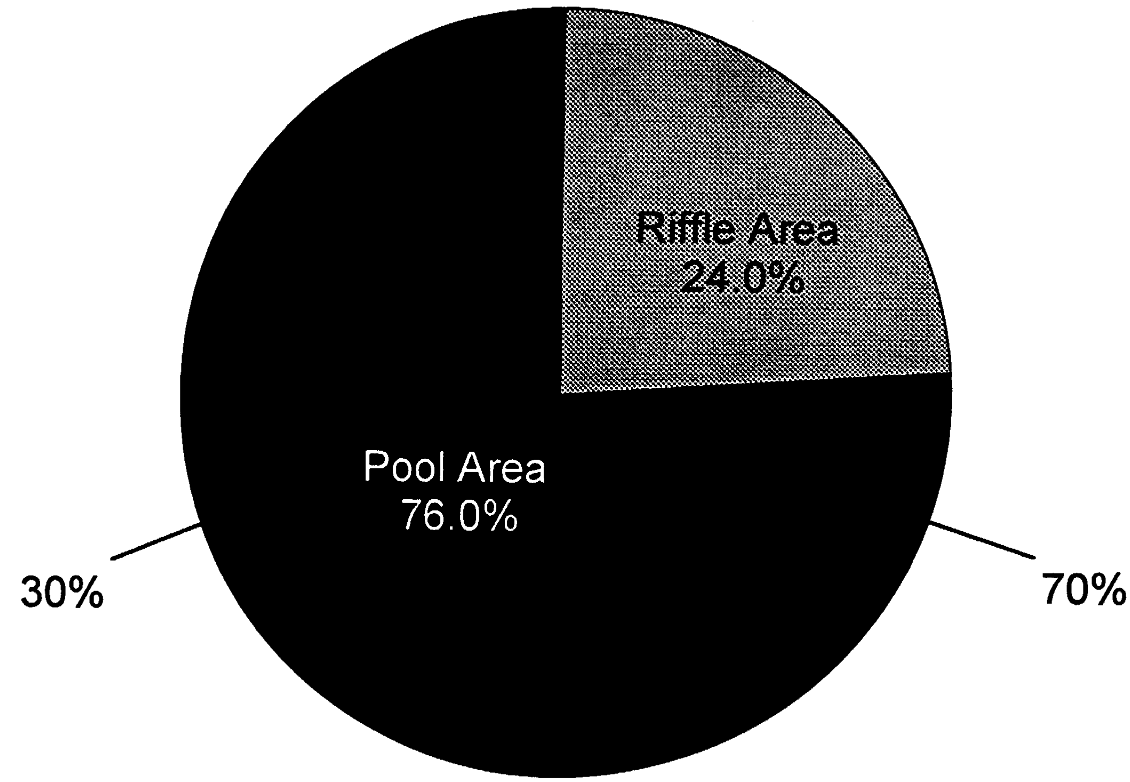


Figure 2. Percent pool and riffle surface area in the lower study section of the Jackson River. The GW-JNF DFC range of 30% to 70% pool surface area is also shown.

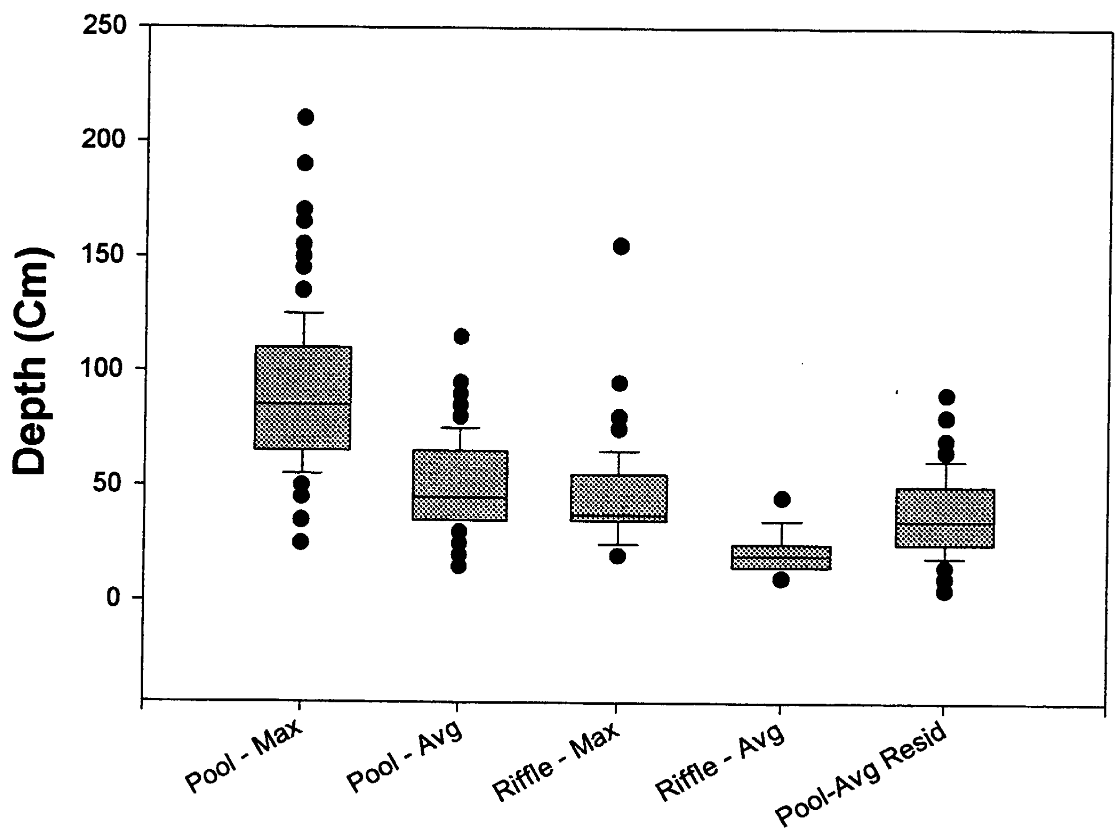


Figure 3. Box plots for habitat-unit maximum and average depths, and average residual pool depth in the lower study section of the Jackson River. The box encloses the middle 50% of the observations, the capped lines below and above the box represent the 10% and 90% quantiles, respectively, dots represent outliers, and the solid line in the box represents the median.

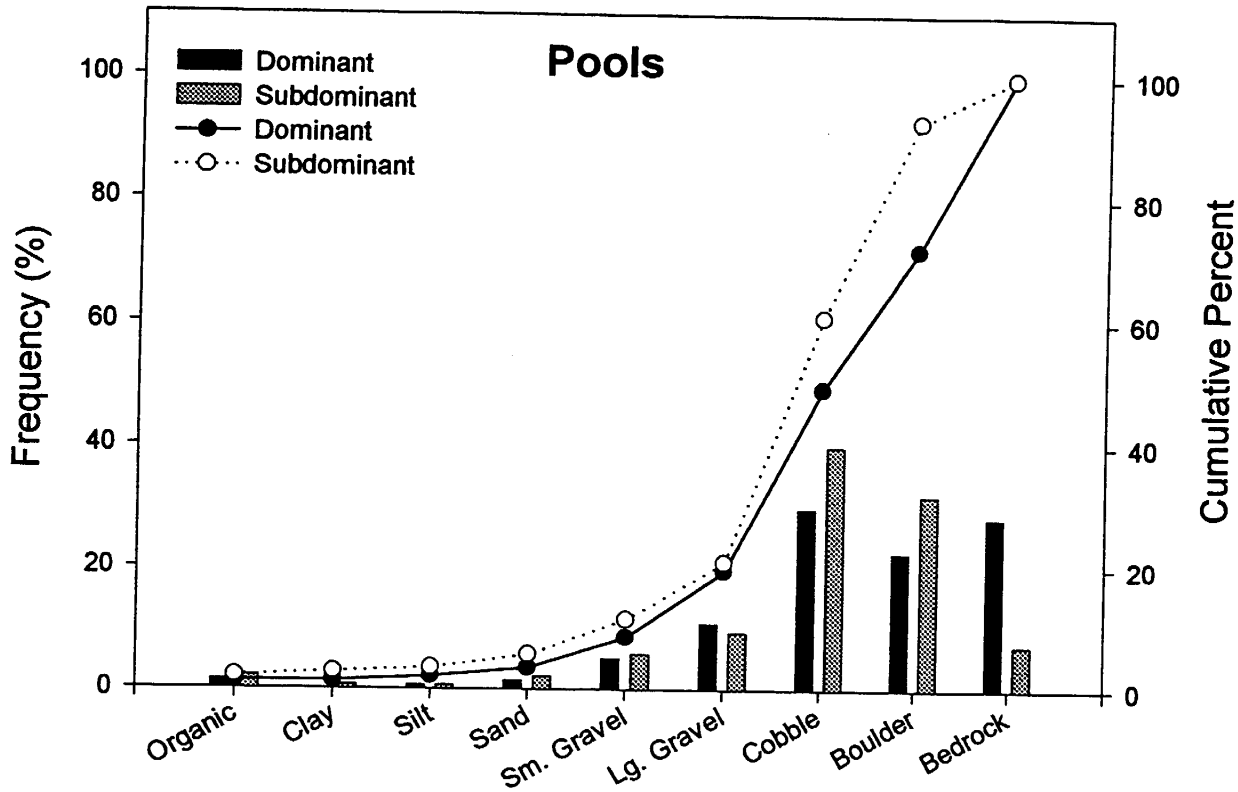


Figure 4. Frequency (percent) of dominant and subdominant substrate occurrence for pool type habitat in the lower study section of the Jackson River. Solid dots represent cumulative percent of dominant substrate and open dots represent cumulative percent of subdominant substrate.

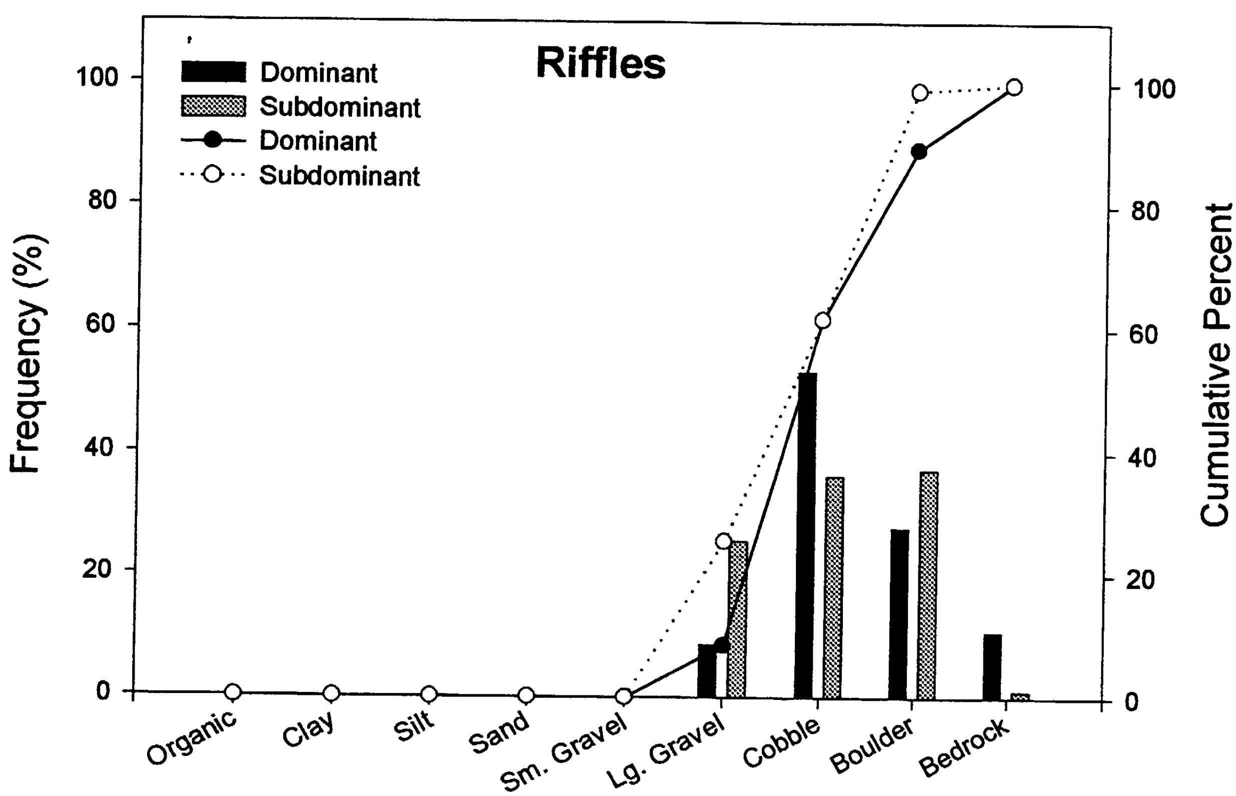


Figure 5. Frequency (percent) of dominant and subdominant substrate occurrence for riffle type habitat in the lower study section of the Jackson River. Solid dots represent cumulative percent of dominant substrate and open dots represent cumulative percent of subdominant substrate.

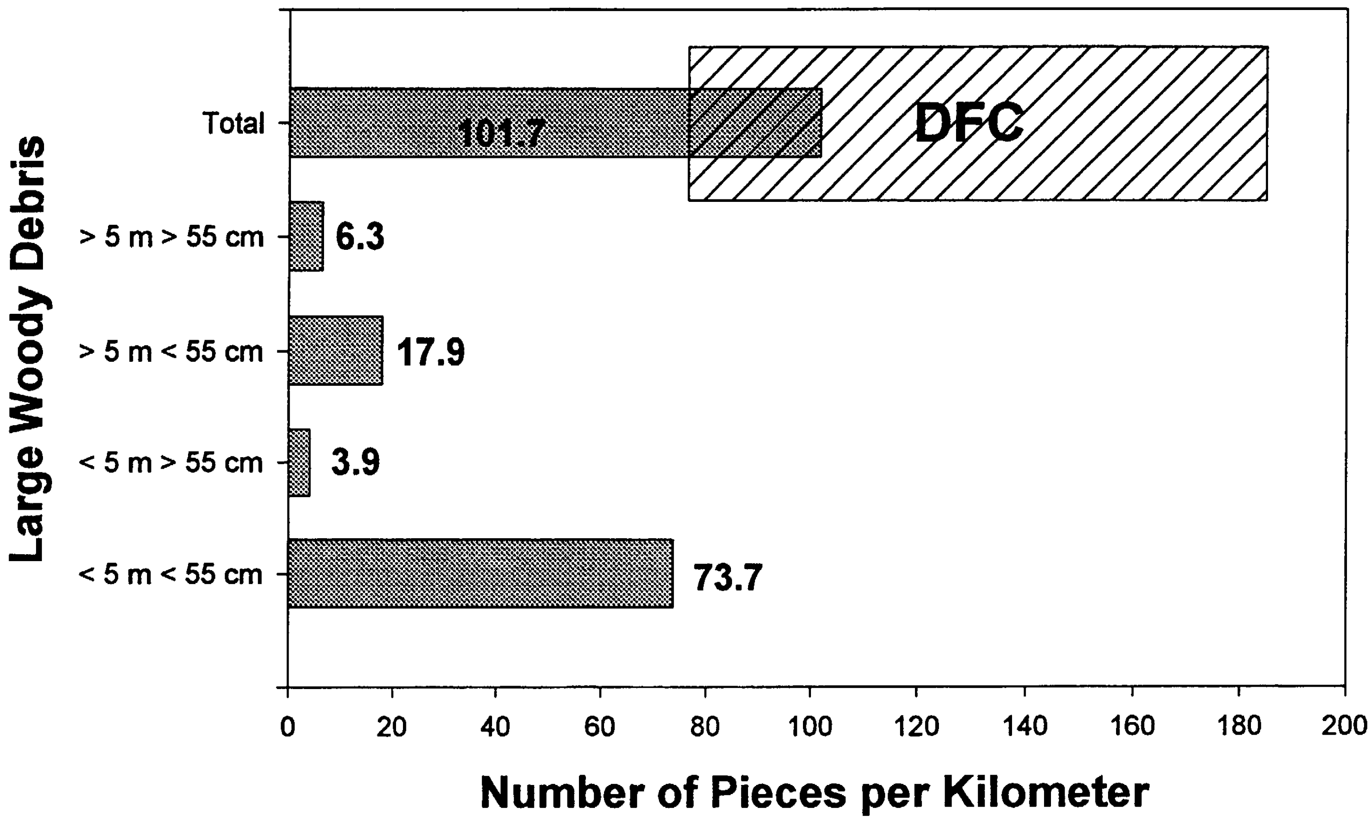


Figure 6. Pieces of large woody debris per kilometer in the lower study section of the Jackson River.

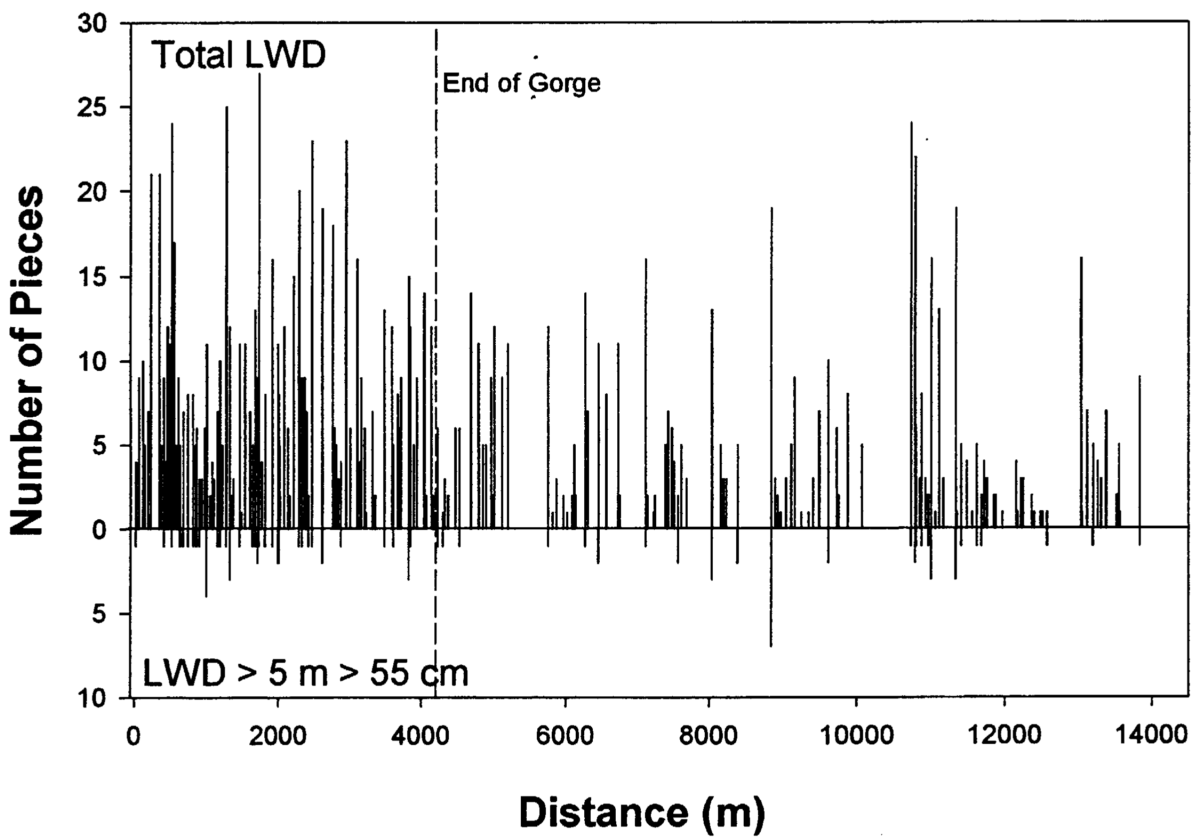


Figure 7. Distribution and total abundance of large woody debris in the lower study section of the Jackson River.

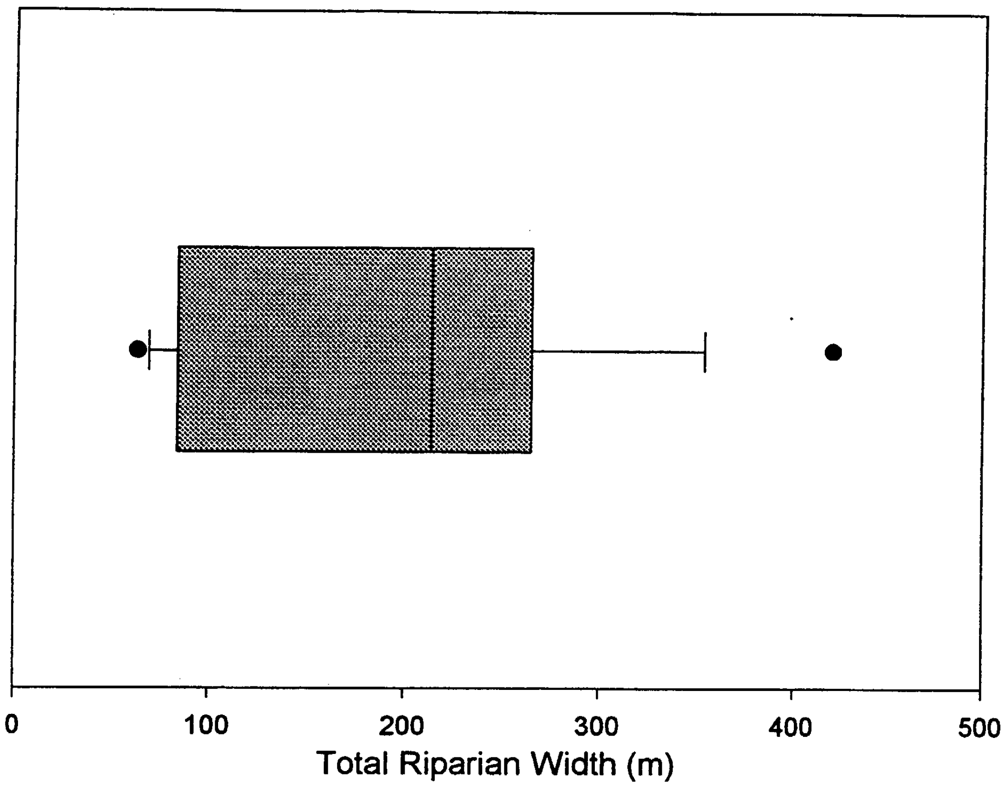


Figure 8. Box plot of total riparian width in the lower study section of the Jackson River. The box encloses the middle 50% of the observations, the bar in the center of the box represents the median, and the capped lines extending above the box represent the 90% and 10% quantiles.

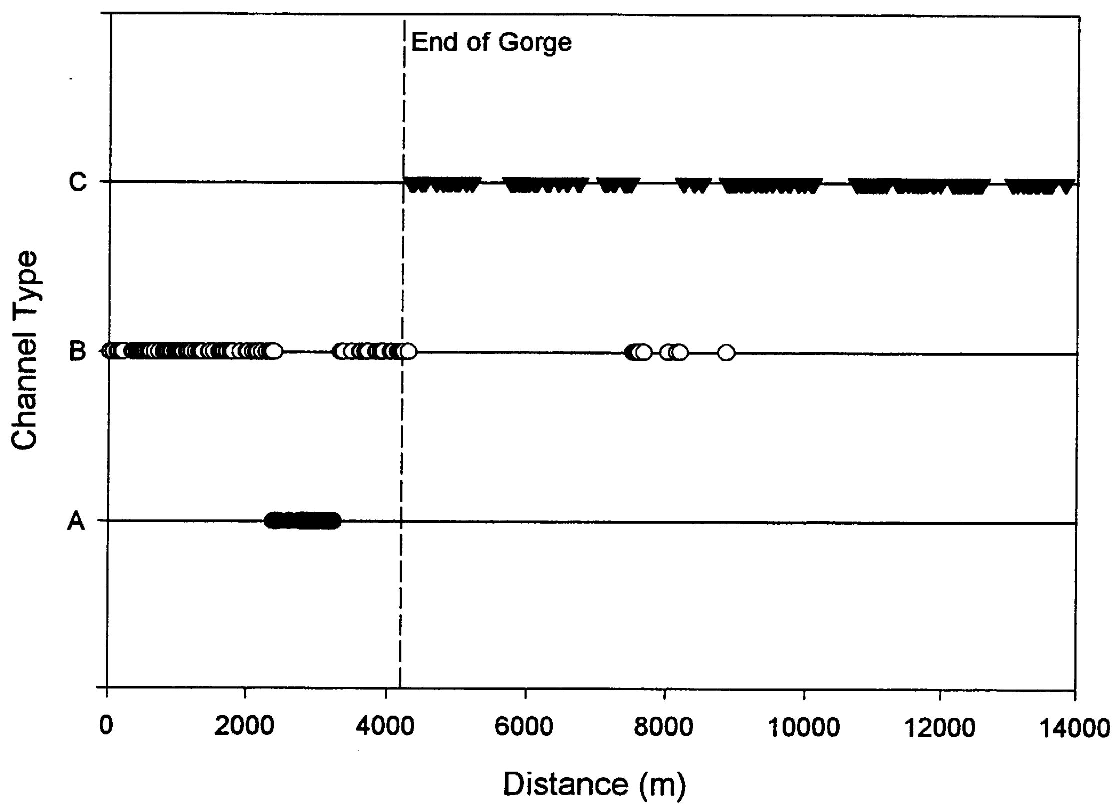


Figure 9. A scatter plot representing the Rosgen's channel type distribution in the lower study section of the Jackson River.

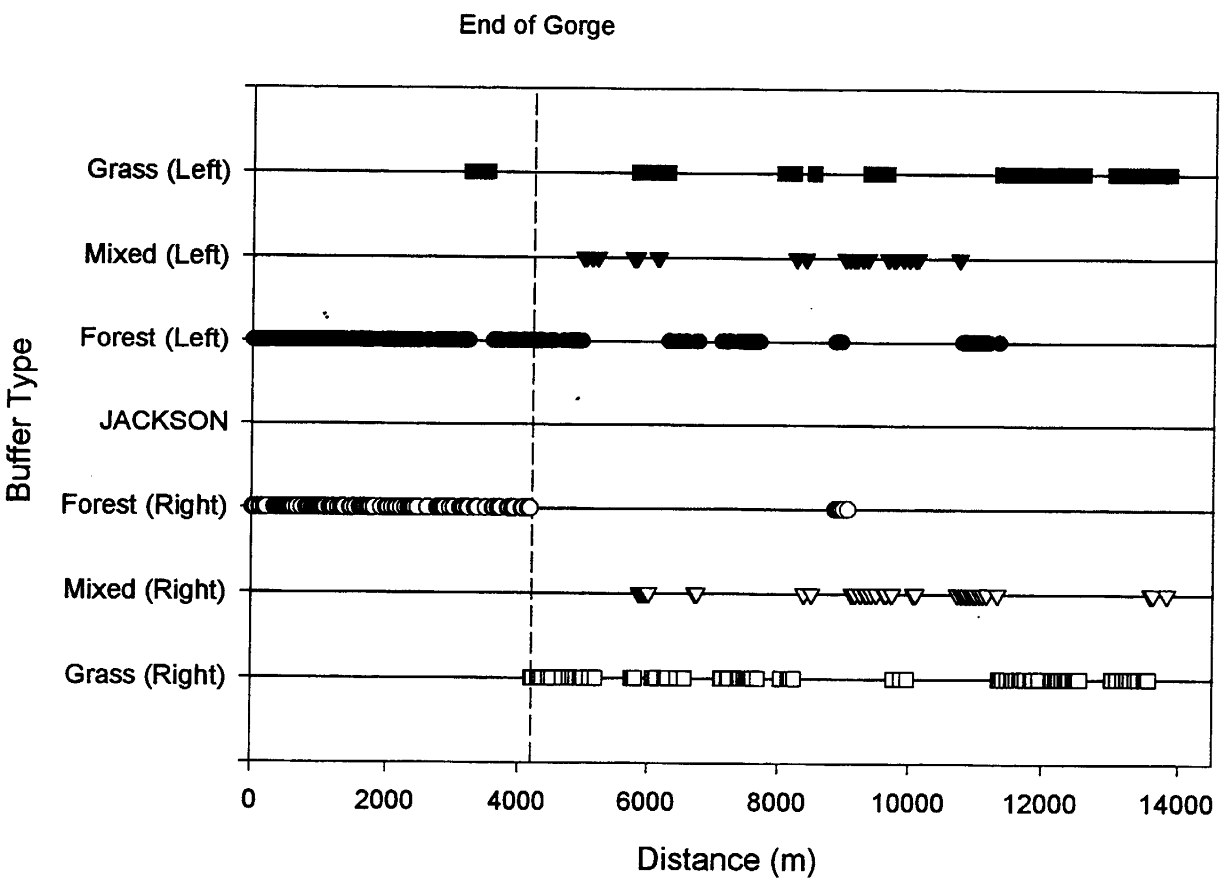


Figure 10. A scatter plot of buffer types for the left and right bank in the lower study section of the Jackson River.

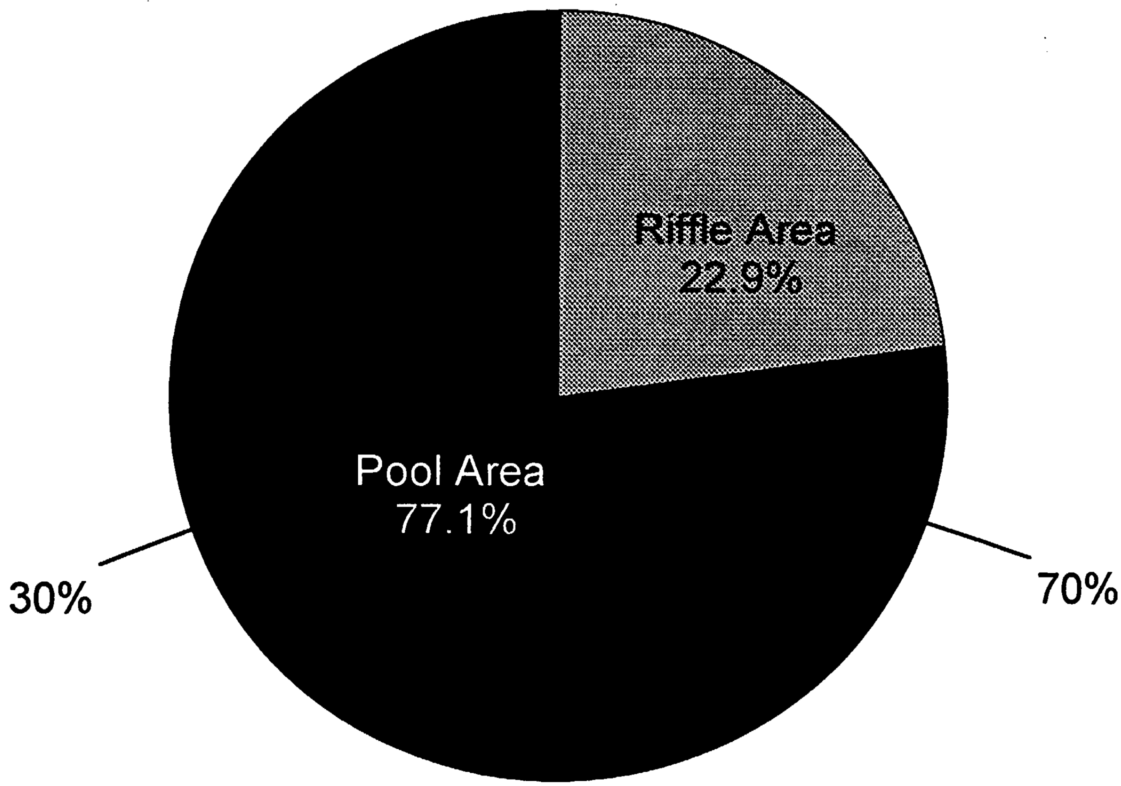


Figure 11. Percent pool and riffle surface area in the middle study section of the Jackson River. The GW-JNF DFC range of 30% to 70% pool surface area is also shown.

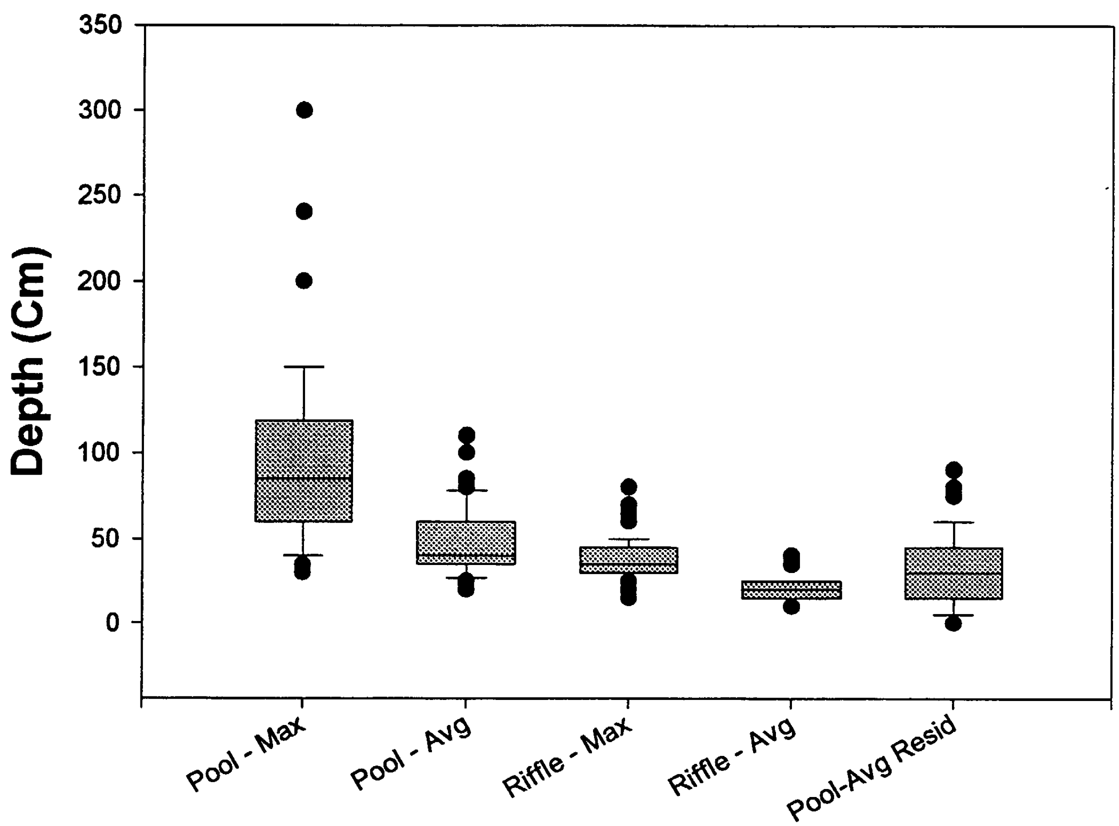


Figure 12. Box plots for habitat-unit maximum and average depths, and average residual pool depth in the middle study section of the Jackson River. The box encloses the middle 50% of the observations, the capped lines below and above the box represent the 10% and 90% quantiles, respectively, dots represent outliers, and the solid line in the box represents the median.

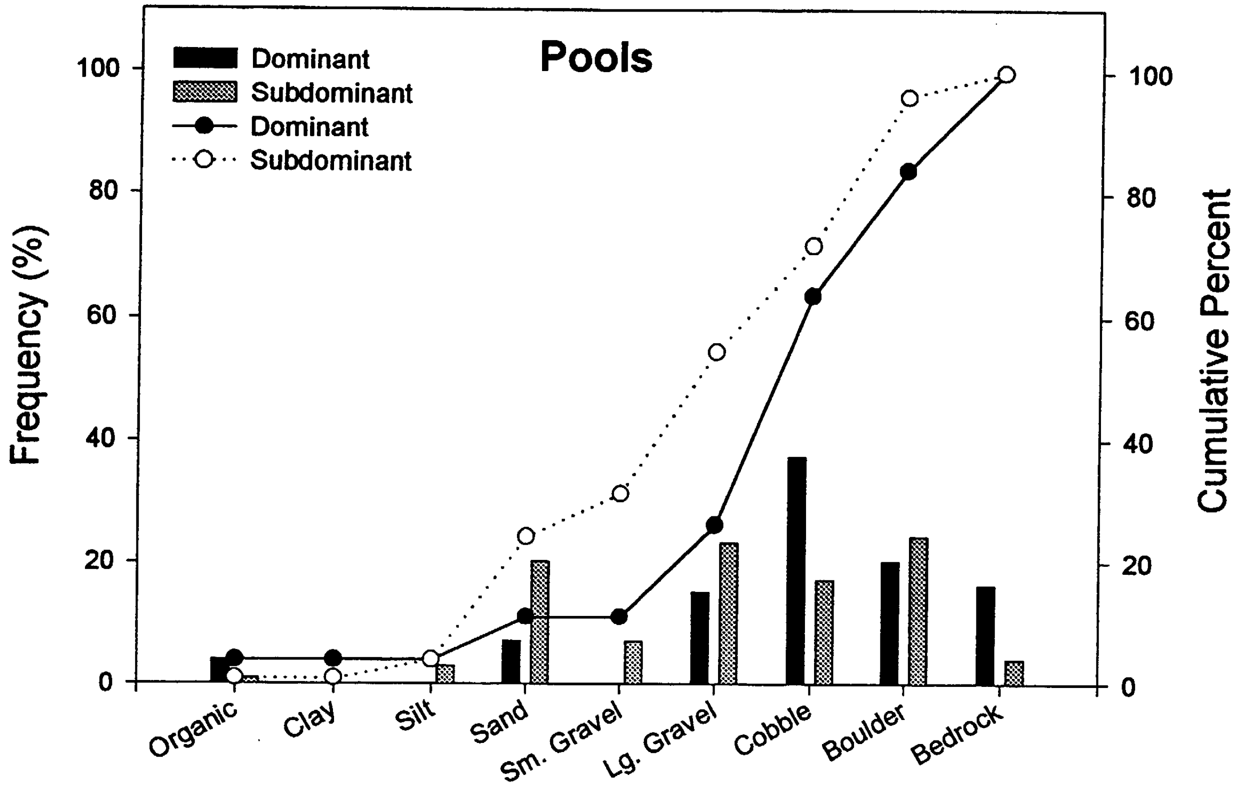


Figure 13. Frequency (percent) of dominant and subdominant substrate occurrence for pool type habitat in the middle study section of the Jackson River. Solid dots represent cumulative percent of dominant substrate and open dots represent cumulative percent of subdominant substrate.

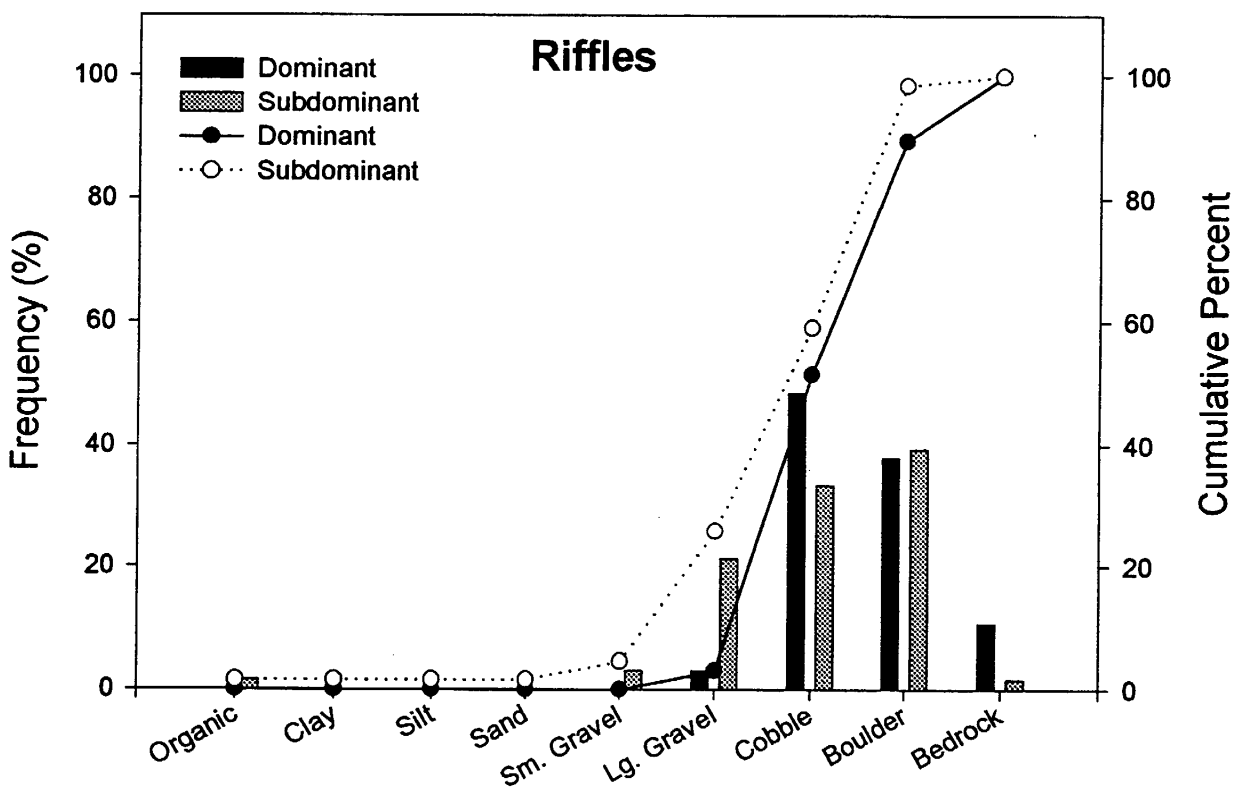


Figure 14. Frequency (percent) of dominant and subdominant substrate occurrence for riffle type habitat in the middle study section of the Jackson River. Solid dots represent cumulative percent of dominant substrate and open dots represent cumulative percent of subdominant substrate.

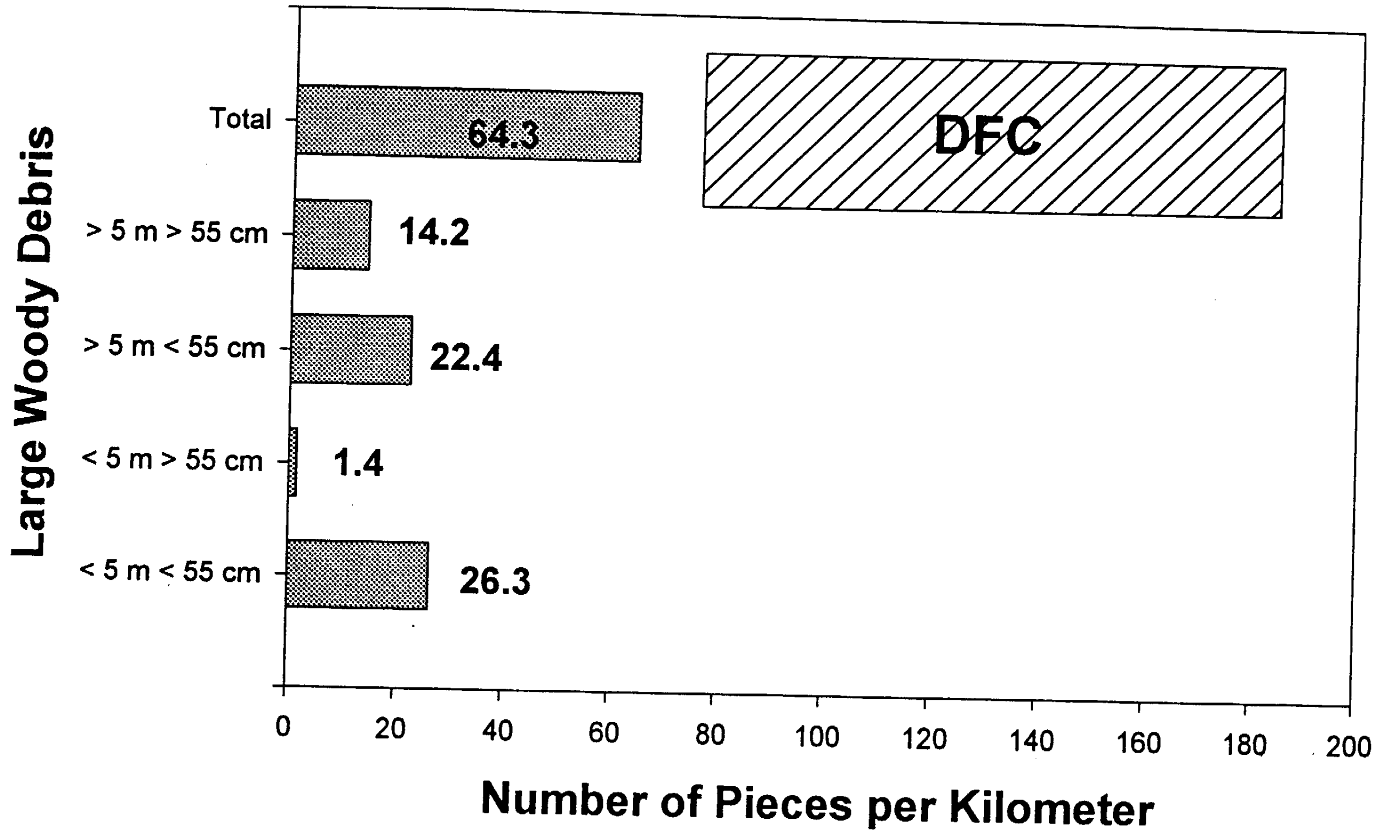


Figure 15. Pieces of large woody debris per kilometer in the middle study section of the Jackson River.

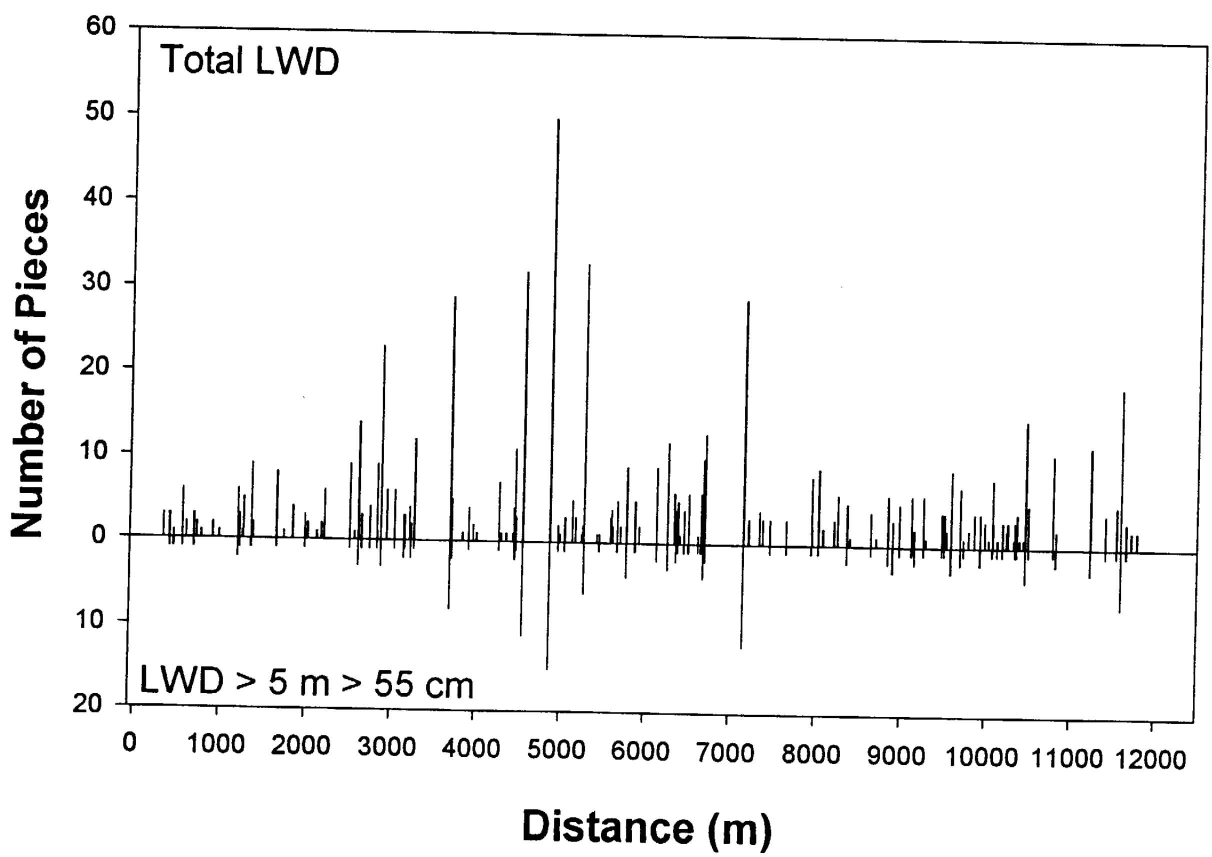


Figure 16. Distribution and total abundance of large woody debris in the lower study section of the Jackson River.

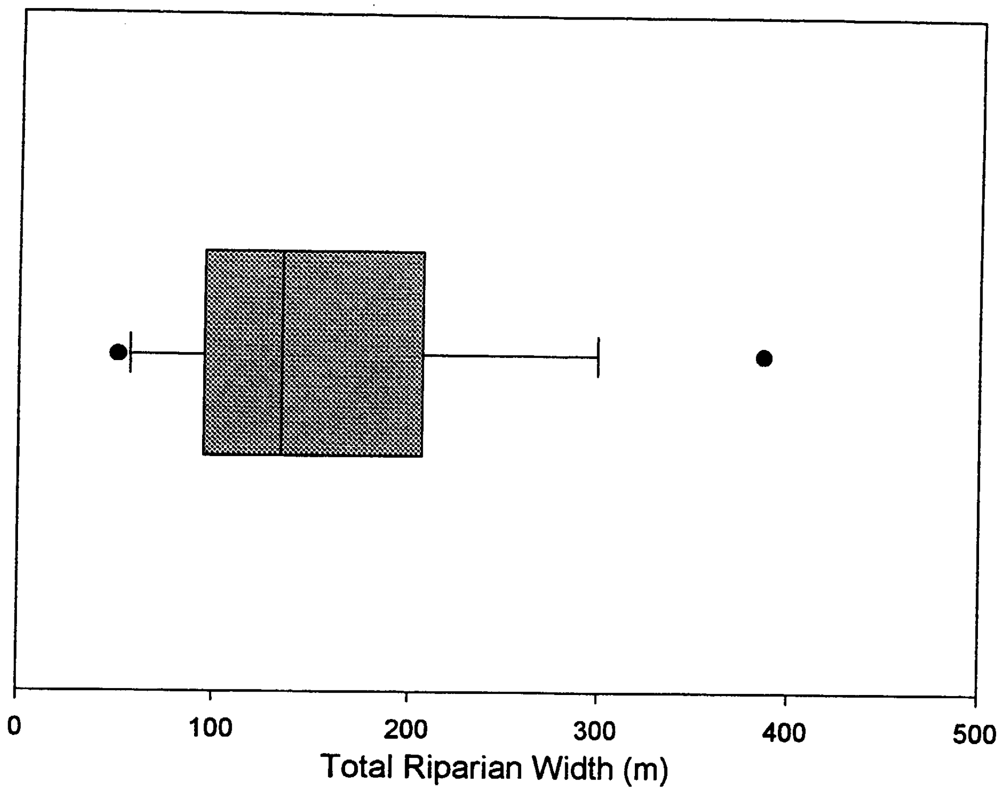


Figure 17. Box plot of total riparian width in the middle study section of the Jackson River. The box encloses the middle 50% of the observations, the bar in the center of the box represents the median, and the capped lines extending above the box represent the 90% and 10% quantiles.

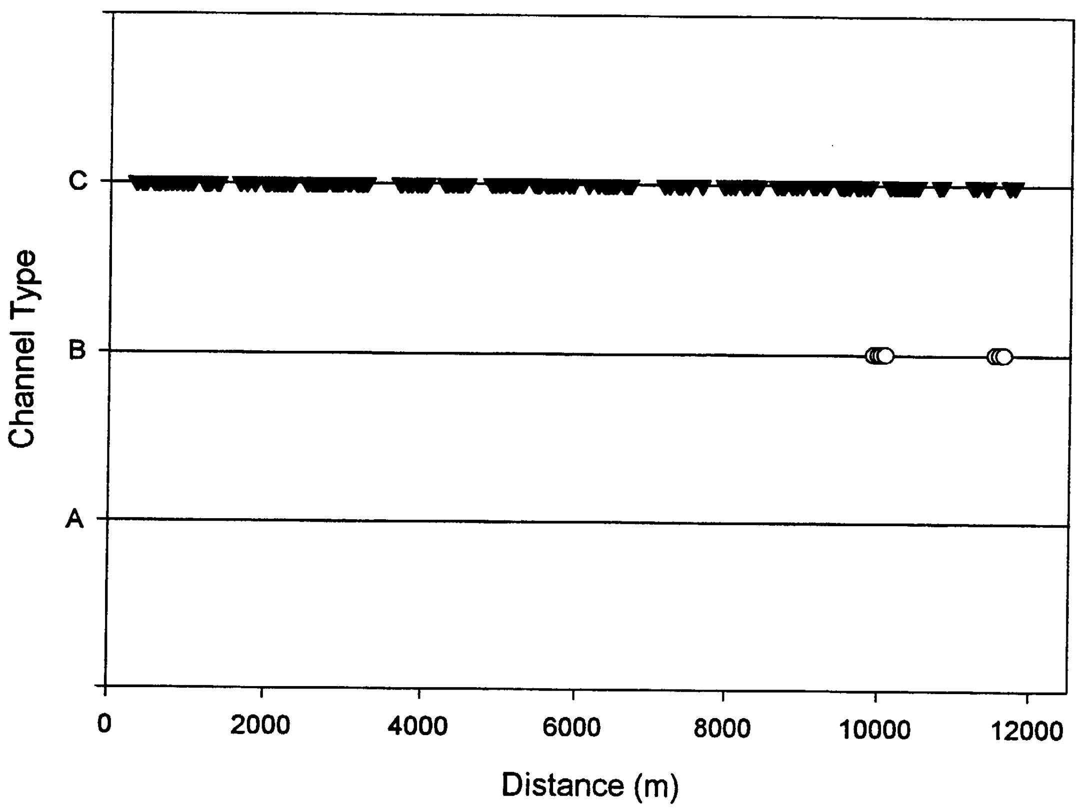


Figure 18. A scatter plot representing the Rosgen's channel type distribution in the middle study section of the Jackson River.

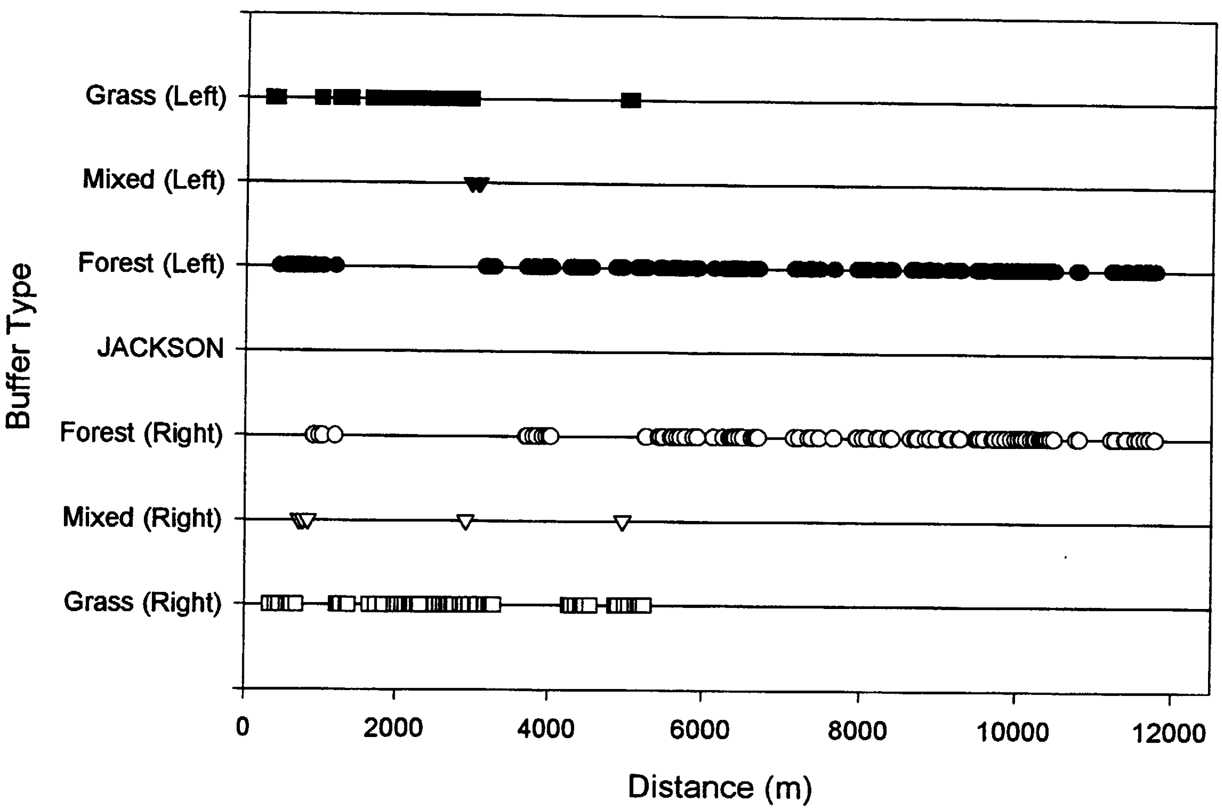


Figure 19. A scatter plot of buffer types for the left and right bank in the middle study section of the Jackson River.

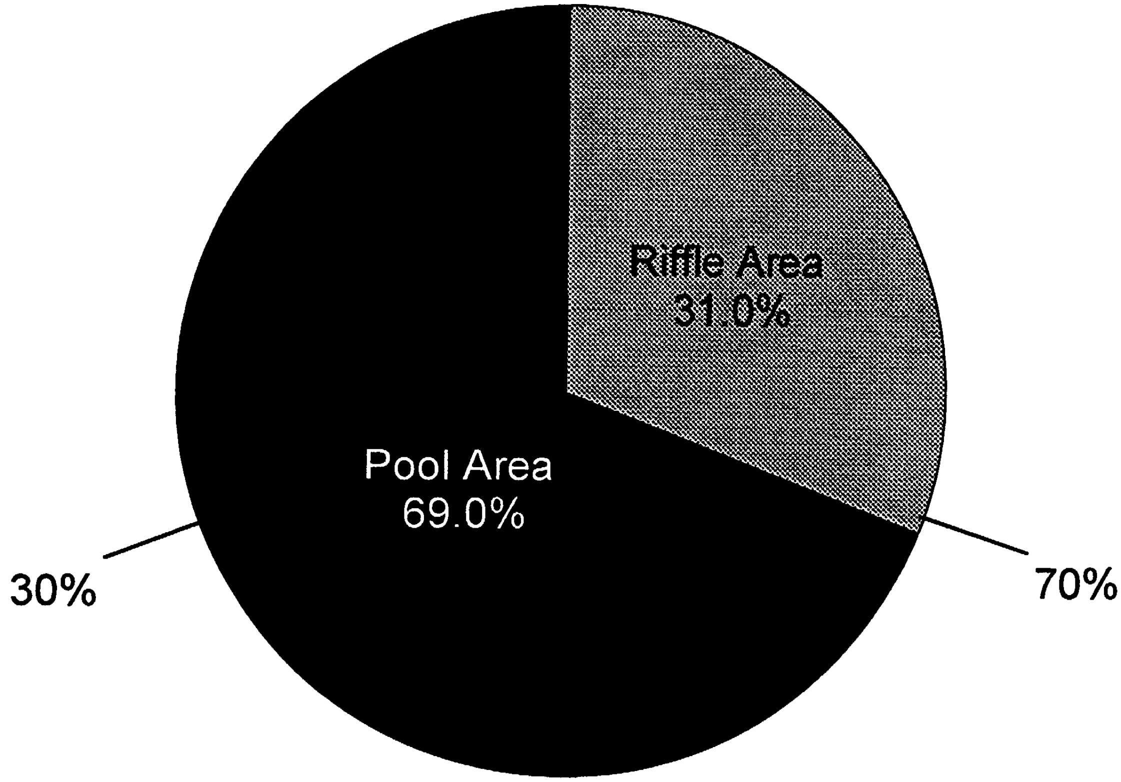


Figure 20. Percent pool and riffle surface area in the upper study section of the Jackson River. The GW-JNF DFC range of 30% to 70% pool surface are is also shown.

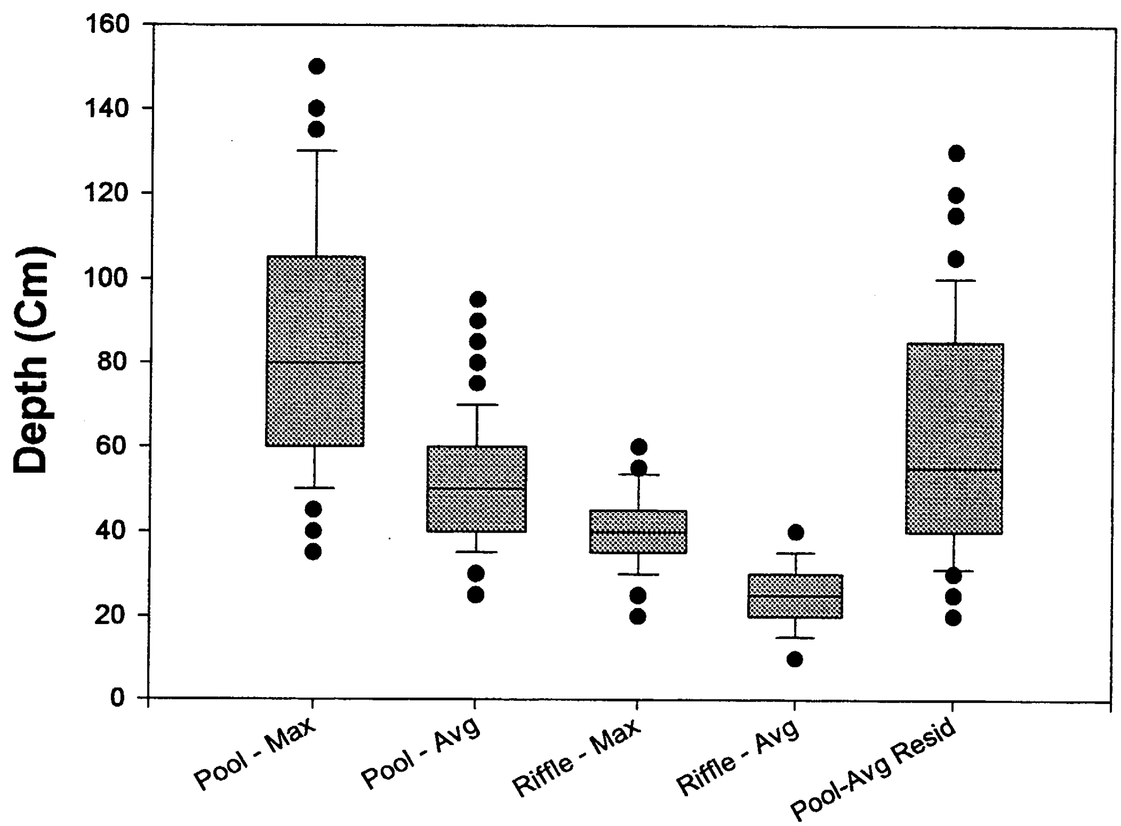


Figure 21. Box plots for habitat-unit maximum and average depths, and average residual pool depth in the upper study section of the Jackson River. The box encloses the middle 50% of the observations, the capped lines below and above the box represent the 10% and 90% quantiles, respectively, dots represent outliers, and the solid line in the box represents the median.

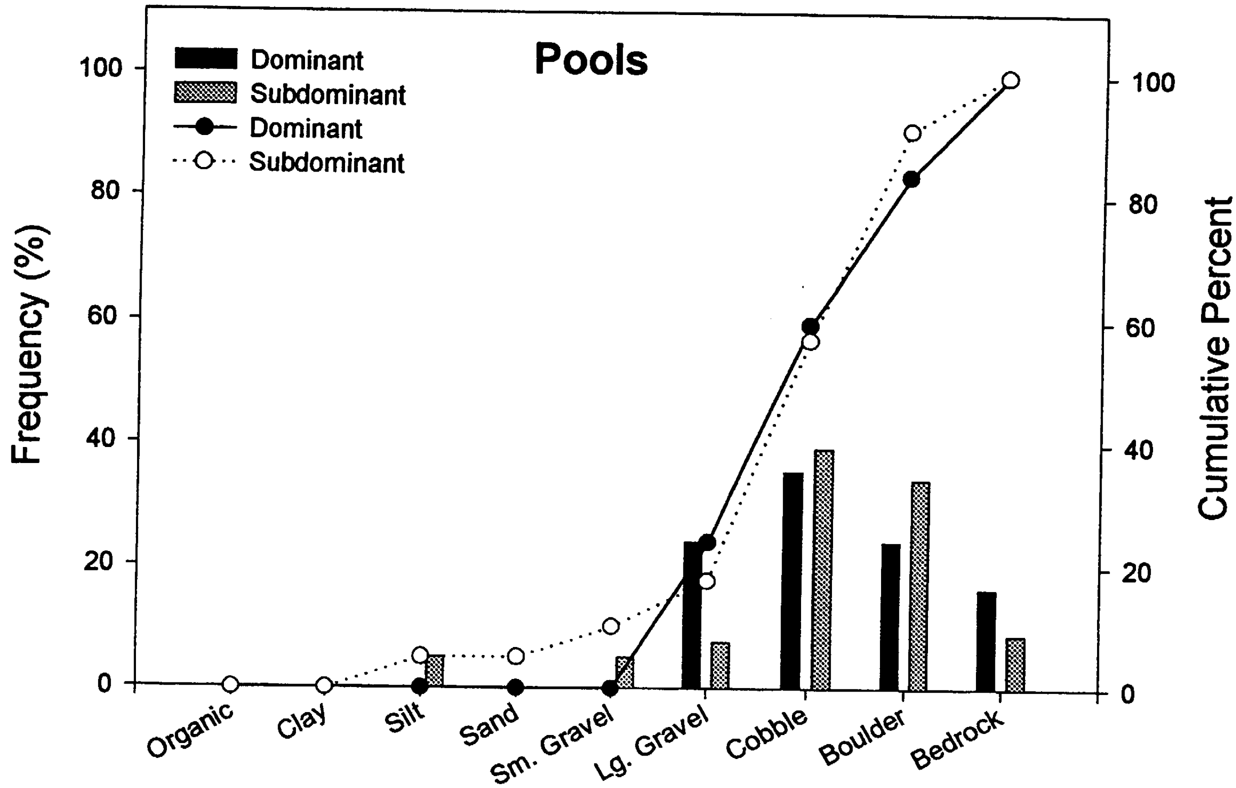


Figure 22. Frequency (percent) of dominant and subdominant substrate occurrence for pool type habitat in the upper study section of the Jackson River. Solid dots represent cumulative percent of dominant substrate and open dots represent cumulative percent of subdominant substrate.

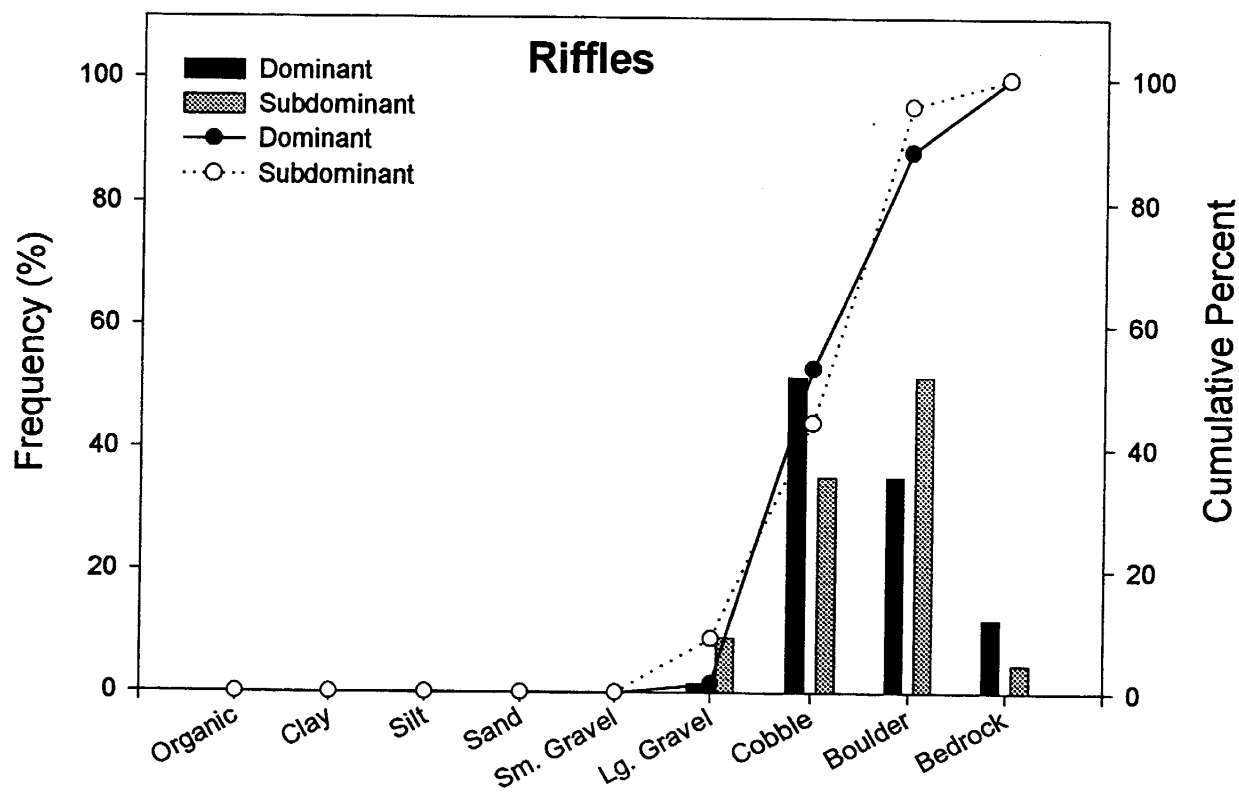


Figure 23. Frequency (percent) of dominant and subdominant substrate occurrence for riffle type habitat in the upper study section of the Jackson River. Solid dots represent cumulative percent of dominant substrate and open dots represent cumulative percent of subdominant substrate.

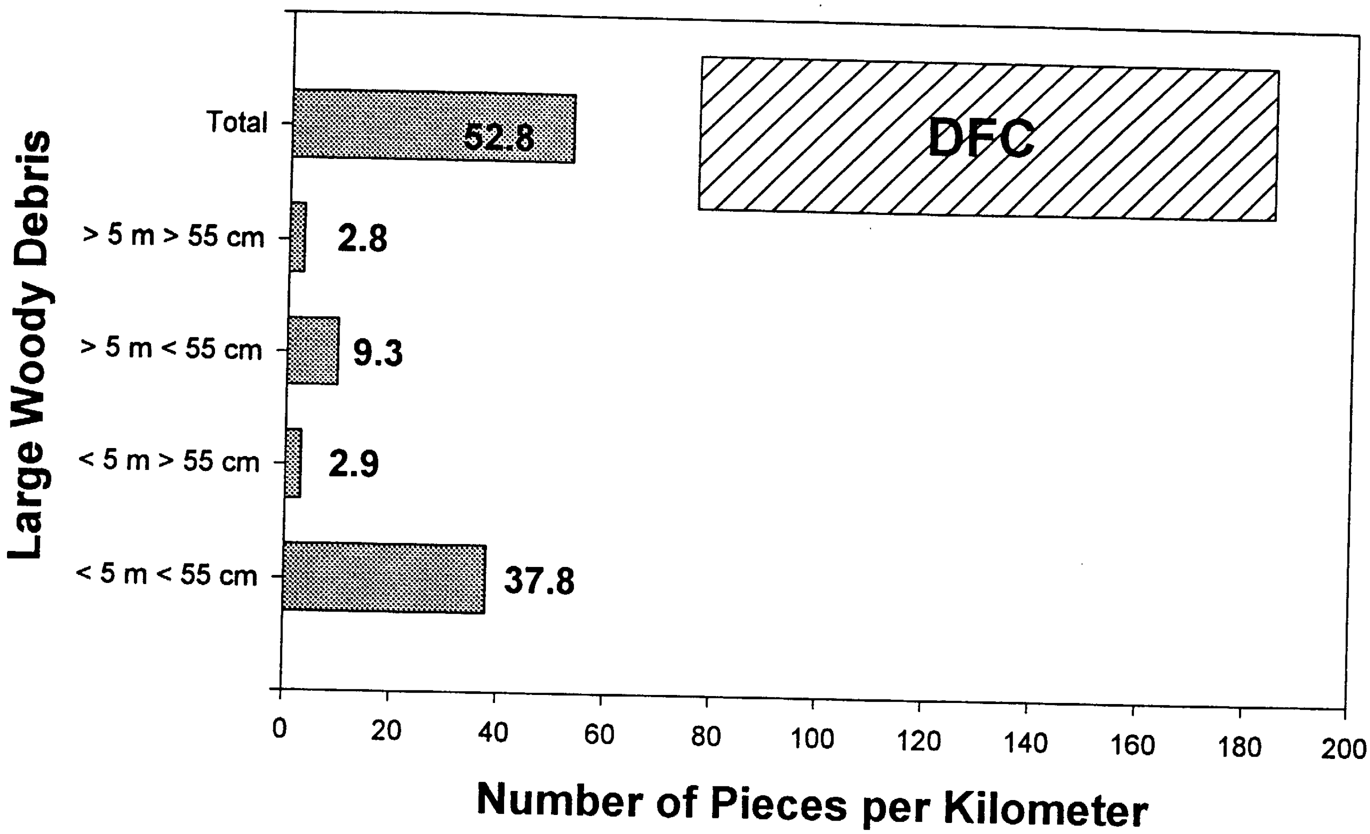


Figure 24. Pieces of large woody debris per kilometer in the upper study section of the Jackson River.

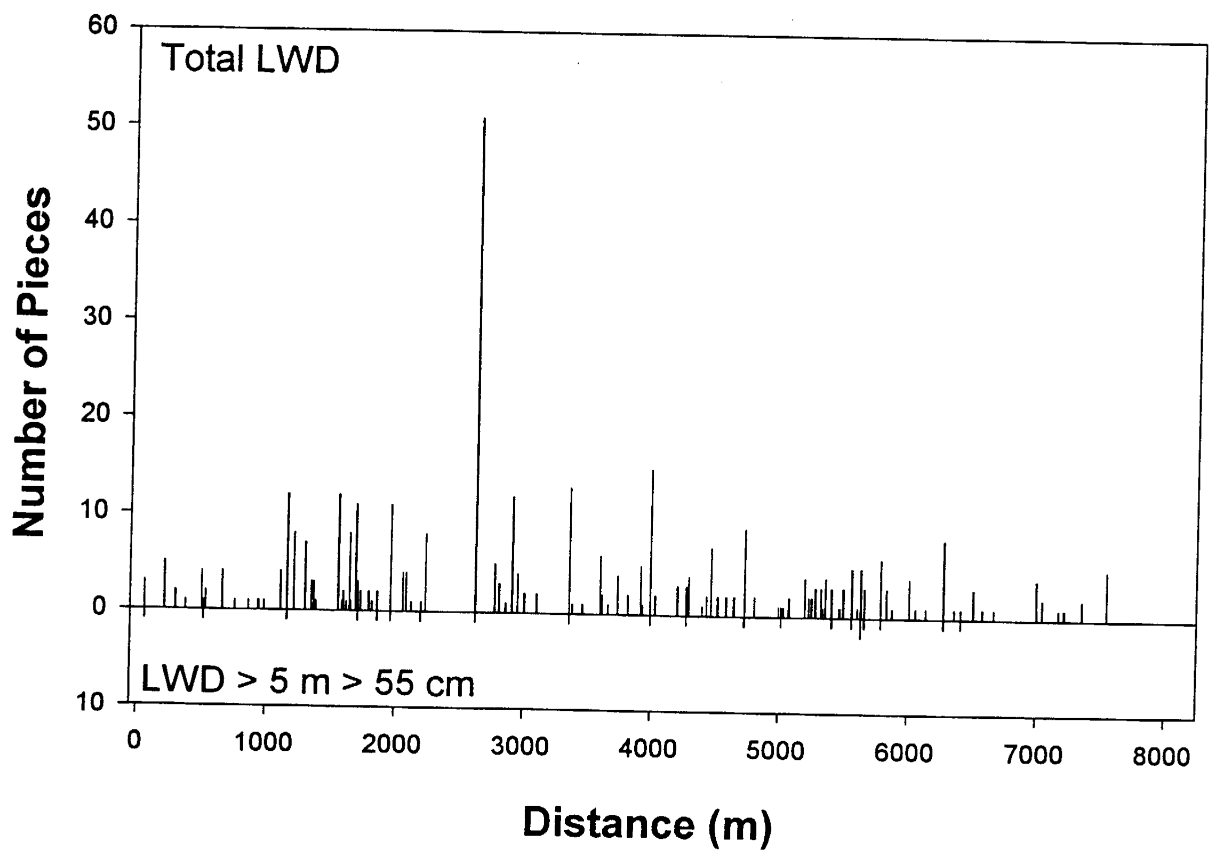


Figure 25. Distribution and total abundance of large woody debris in the upper study section of the Jackson River.

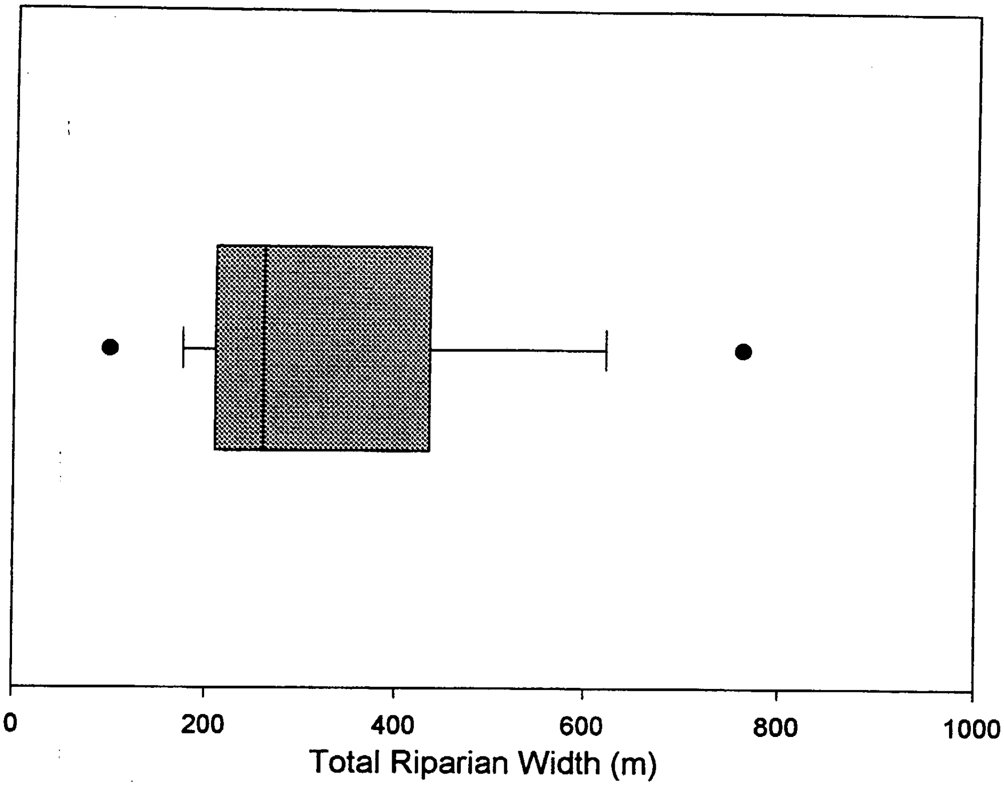


Figure 26. Box plot of total riparian width in the upper study section of the Jackson River. The box encloses the middle 50% of the observations, the bar in the center of the box represents the median, and the capped lines extending above the box represent the 90% and 10% quantiles.

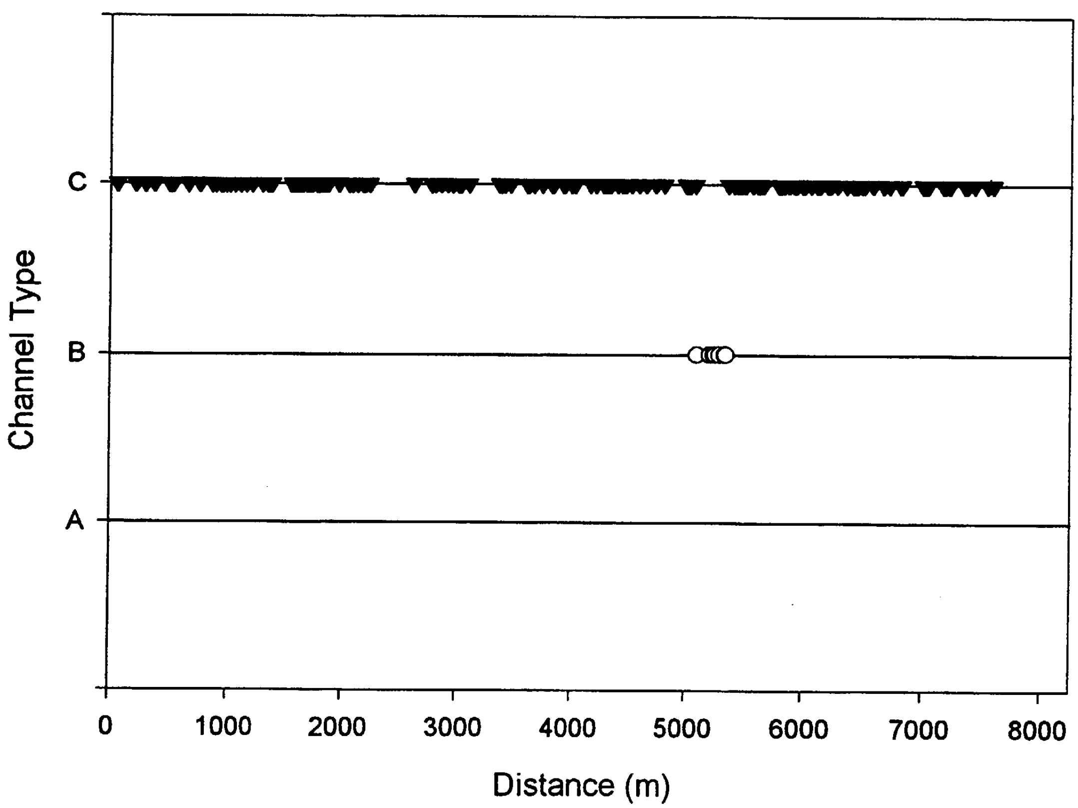


Figure 27. A scatter plot representing the Rosgen's channel type distribution in the upper study section of the Jackson River.

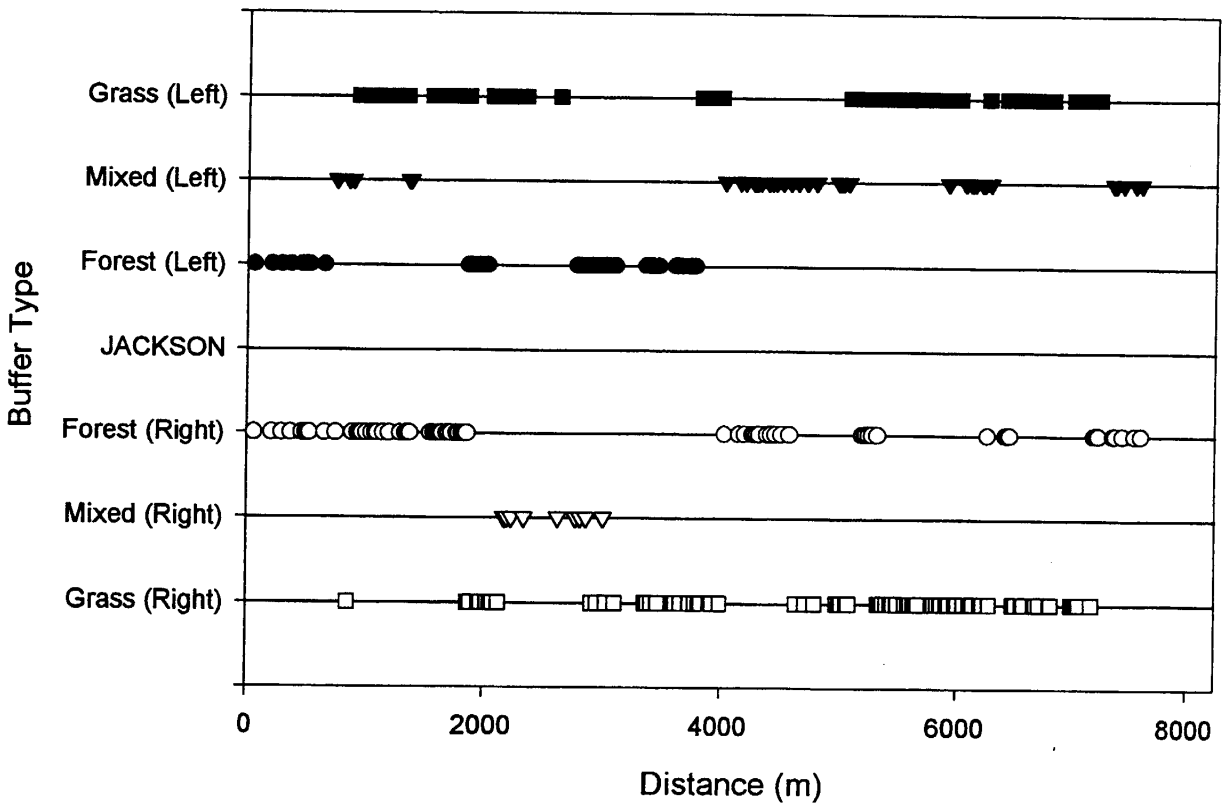


Figure 28. A scatter plot of buffer types for the left and right bank in the upper study section of the Jackson River.

Appendix 1a. Substrate classification criteria.

SUBSTRATE CLASSES

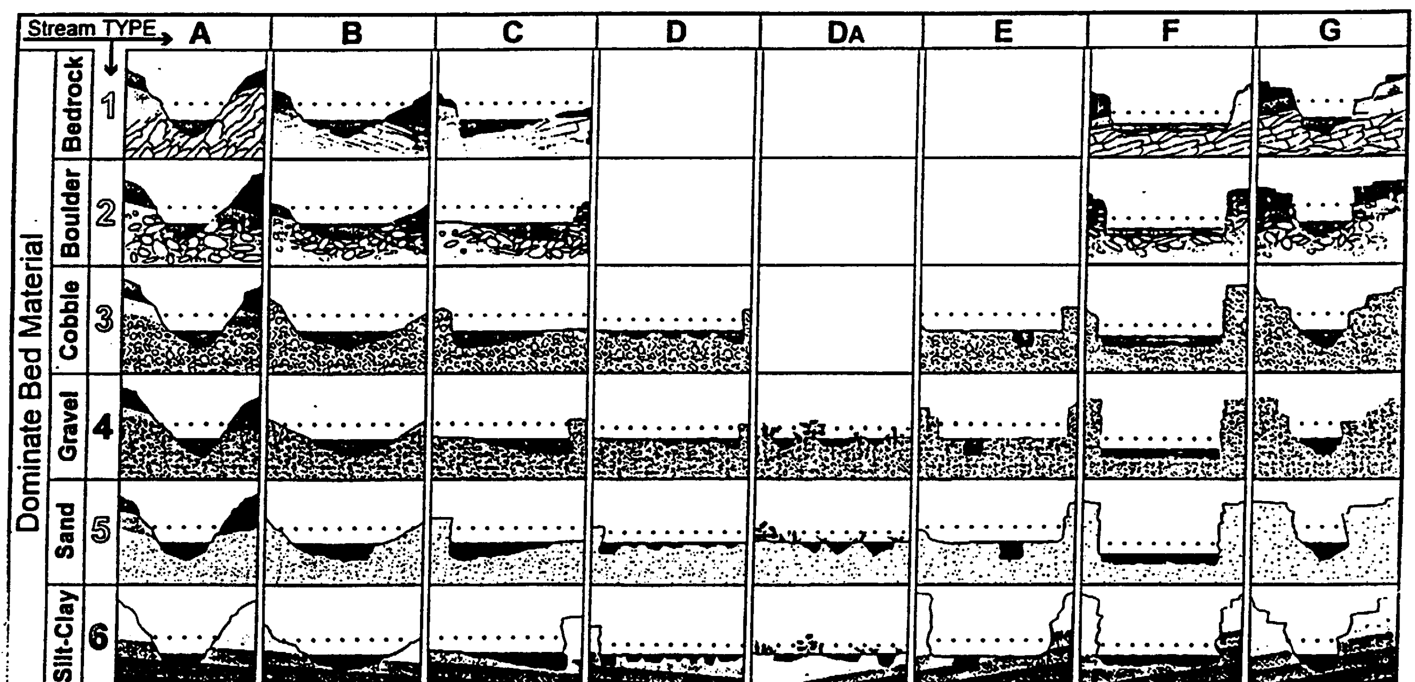
1 organic debris
2 clay
3 silt
4 silt- 2mm sand
5 2-10mm small gravel
6 1-10cm large gravel
7 11-30cm cobble
8 30cm boulder
9 bedrock

Appendix 1b. Large woody debris (LWD) classification criteria.

LWD SIZE CLASSES

1 < 5 m (length) and < 55 cm (diameter)
2 < 5 m (length) and > 55 cm (diameter)
3 > 5 m (length) and < 55 cm (diameter)
4 > 5 m (length) and > 55 cm (diameter)

Appendix 1c. Rosgen's channel type criteria, table from Rosgen 1996.



Entrchmnt	< 1.4	1.4 - 2.2	> 2.2	n/a	> 4.0	> 2.2	< 1.4	< 1.4
W/D Ratio	< 12	> 12	> 12	> 40	< 40	< 12	> 12	< 12
Sinuosity	1 - 1.2	> 1.2	> 1.2	n/a	variable	>1.5	> 1.2	>1.2
Slope	.04-.099	.02-.039	< .02	< .04	< .005	< .02	< .02	.02-.039

Appendix 2a.	Comments made during survey with corresponding hipchain distances.		
Distance	**Comments**		
0.0	Begin survey at Back Creek confluence		
765.0	**Spring**		
1481.0	**Spring**		
2349.6	Tributary on right		
2411.2	Mini falls		
2749.6	Rip rap on right		
3036.0	Houses start		
3156.5	Country club on left		
3216.0	Bridge		
3313.0	Bridge and man-made dam		
3484.2	Man-made dam		
4189.1	Tributary on right		
4479.0	Cable crosses stream		
4407.4	Tributary on right, Rowan Branch		
5071.2	**Spring**		
5915.8	Ford		
5916.8	Tributary on right		
7054.6	Tributary on right		
7683.0	Ford		
9256.4	Rip rap on left		
9196.4	Tributary on right		
9616.0	Tributary on left		
10412.0	**Spring**		
10563.0	**Spring**		
10519.8	Bridge, Rt. 39		
11954.1	Ford		
12010.8	Pipe in stream		
12622.0	**Spring**		
13052.9	Bridge		
13336.1	Tributary on left		
13432.0	Pipe in stream		
13563.9	Rip rap on left		
14164.7	Start midsection at Forest Service boundary		
14364.6	Tributary on left		
14551.5	Restoration project on right		
14738.2	Restoration project on left		
15096.0	Seep		
15384.4	Small tributary on right		
15796.7	Tributary on right		
15910.5	Mansion on left		
16065.4	Bridge for mansion driveway crosses here		
16430.8	Dry tributary on right		
17522.3	Restoration project on right		
18240.0	Dry tributary on right		
18718.0	Dry tributary on right		
18974.5	Swinging bridge		
19011.0	Ford		
23123.9	Trail crossing		

Appendix2a.	Continued		
23577.0	Trail crossing		
23692.1	Campground left, cliff on right		
24064.4	**Spring** in from left bank		
24135.0	Campground left		
24168.1	Tributary on left		
24566.8	Small, dry tributary on left		
24841.8	Small, dry tributary on left		
25418.1	Camping spot on left		
25482.6	Camping spot on left		
25610.7	End second section		
25613.5	Dry tributary on left, Ned Hollow		
25826.7	Private property on right side, Forest Service on left		
25989.0	Private on both sides		
26273.6	Tributary on left, cold water		
26712.1	Dry tributary on right		
27391.0	Broken pipe in stream		
27434.9	Forest Service property on left		
27476.5	Rt. 623 bridge		
27512.3	**Spring**		
27600.3	Private property on both sides		
27957.5	Man-made deflector in stream		
28391.4	Power lines cross here		
28426.2	Forest Service property on left		
28528.9	Tributary, Gillet Branch, on right		
29432.7	Ford		
29522.9	Bridge for RT 220		
29548.3	Fenced-in area in stream		
29777.5	**Spring** from left bank		
29892.1	Outflow from pond		
29953.5	**Spring** in from left bank		
30691.5	Fence in stream		
30834.6	Dry tributary on left out of culvert		
30994.7	Suspension bridge		
31026.0	Ford		
31057.4	Power lines cross here		
31290.4	**Spring** from right bank		
31480.0	Tributary on left		
31604.8	Cattle access		
31895.2	Tributary on left		
32303.1	Tributary on left		
32680.0	Bridge to private property		
33208.2	End of survey		